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Original Research

Developing an Agility Model Focusing on Delivering Products to the Customers in the Supply Chain of Perishable Goods

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Abstract

The producer can warehouse the perishable items and reuse them in the production line by creating an appropriate cooperation relationship and sharing information related to demand and stocks in order to provide the field to save money, reduce the environmental population, and use natural resources less. Therefore, it is also necessary to use the concept of the supply chain of perishable items in the supply chain. In this study a new approach will be provided to develop the agility of the supply chain to establish an integrated and agile supply chain to create an informational and operational linking bridge between different sections of the supply chain. Hence, a multi-objective mathematical model will be presented considering the maximization of the level of agility, the minimization of the perishing of goods, minimization of the time of distributing goods by systemizing the retail distribution system and since the agile supply chain model is considered as difficult problems, Epsilon- Constraint method and Benders Exact Solution method will be used to develop this research. Benders method is a decomposition algorithm that creates smaller sections of agility in solving the model by decomposing the mathematical model. First, the model is evaluated, and a problem is designed to assess the performance of the proposed model, and it is solved by using GAMS and CPLEX solver. Then the validity of the provided model is analyzed by the approach of the meta-heuristic algorithm Moka.

Keywords: Agility Model, Supply Chain, Perishable Goods.

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Introduction

The philosophy of supply chain management is to increase the cooperation and improve the communication between the internal sections of organizations, as well as the companies and organizations as the chain loops. The inconsistency and lack of integration are considered as one of the main reasons for the decreased supply chain performance, especially for the core supply chain companies (Horvath, 2001). The agile supply chain is one of the main and important parts of the economy of every country, and its related costs are among the important constitutive costs of the prime cost of final products. Today, due to the more competitive business market, organizations need to decrease some costs, including transportation costs in the goods distribution system and their supply chain, in order to lower the prime cost of final products. Also, the need for systems that can carry out agile transportation operations as efficiently as possible attracts more attention because of a growing trend of civilization and industrialization. Also, according to the reduction of fuel reserves in the world and the growing need for optimizing energy consumption in all organizations, planning transportation is important to reduce energy consumption and costs and also reduce the population, followed by reducing health spending and social problems (Tapia-Ubeda et al., 2018). In addition to mentioned reason, pro-environmental organizations legislate laws based on reducing carbon emissions because of global warming; therefore, reducing the consumption of fossil fuel should be considered as a basic goal, especially in the field of transportation planning, and attract more attention than other goals including the minimization of the total time of transportation (lead time) and mileage (Neves Almeida & Marques, 2021). The mentioned reason causes all organizations all over the world to consider the improvement of their transportation planning as the most important executive program, and accordingly, many researchers study and investigate mentioned problems in this field. One of the most influential components in the supply chain to which paying attention causes agility in the supply chain in the field of retail distribution is the reduction of lead time to costumers. One of the challenges ahead is in lead time to customers recently, which lead in destroying and perishing of products due to latency in delivery lead time also has a key role in the supply chain of perishable products. The delivery of products at an appropriate timing satisfies customers for their purchase of perishable goods, and the development of costumers to the supply chain is stated by the definition of the soft and hard time window of this topic. Therefore, the development of an agile supply chain has a key role in on time delivery, the delivery of high-quality products and customers' satisfaction. According to what mentioned above, new approach will be provided to develop the agility of supply chain in this paper to establish an integrated and agile in supply chain to create information and operational linking bridge between different sections of supply chain. Hence, a multi-objective mathematical model will be presented in this paper considering the maximization the level of agility, the minimization of the perishing of goods, minimization of the time of distributing goods by systemizing the retail distribution system. Therefore, because the agile supply chain model is considered as difficult problems, Epsilon- Constraint method, for assessing the Pareto frontier of optimized responses, and Benders Exact Solution method, because studied supply chain is NP-HARD, will be used to develop this research. As we know, Benders method is a decomposition algorithm which creates smaller sections of agility in solving the model by decomposing the mathematic model.

Literature Review

Mirzabaghi et al. (2021) introduces the problem of sustainable routing of heterogenous vehicle in a network with direct and reverse flows where different economic, environmental and social factors are considered as a two-objective mixed integer linear programming mathematical model. The aim of the problem is to design serviceability routs and determine transportations' vehicle velocity so that minimizes fuel-consumption rate as well as pollution arising from transportation and, on the other hand, balances the workload of different transportation vehicles in terms of active lead time to satisfy drivers. A comprehensive function has been used to estimate the fuel-consumption rate in which the fuel-consumption rate is a function of departed distance as well as velocity, the amount of load, and technical characteristics of transportation vehicles. The exact form of an augmented constraint method is used to solve the problem and also to solve the problem in large dimensions, and two multi-objective meta-heuristic algorithms based on the Genetic algorithm and Fireworks Algorithm have been developed. The results of solving different examples indicate better performance of the Fireworks algorithm. The analysis of Pareto points also shows that the longest tour can be reduced even up to 20%, and the spread between the working lives of different vehicles can be reduced to 15% by increasing by about 1% of fuel costs. Also, this spread can be reduced to 25% by increasing by about 3% of fuel costs.

Seif Barghi (2020) stated in his research that numerous studies were conducted about touring-locating according to the intense competition of companies for serviceability and intense competition in the global market. The problem of routing-locating with the reduction of pollution produced by vehicles for order fulfillment in multigraph networks and the possibility of comprehensive disturbance has not been seen. Every problem has been investigated separately, and no locating problem with multi-graphs has been seen. In this paper, a new routing-locating model has been introduced, considering the pollution of vehicles in multigraph networks and the possibility of disturbance. In this model, vehicle maneuver depends on the time and traffic conditions. The aimed function is the model of the minimization amount of produced population by vehicles and the reduction of operational costs such as purchasing vehicles, constructing a store, and the salary of drivers according to the duration of travel. The model is provided as Two-Stage Stochastic Optimization to consider disturbance. At the end of the paper, a Genetic algorithm has been used to solve the model on a large scale, and the response and time of solving in exact mode have been compared to assess the accuracy of the meta-heuristic algorithm. According to the results of solving, the model tries to reduce the produced pollution and operational costs simultaneously, such as not constructing warehouses in crowded places and not traveling vehicles in peak traffic time.

Bolvardi et al. (2020) stated that planning business traveling is one of the basic problems for urban planners in developed and even developing countries. The importance of this planning is that this problem deals with three factors, including costs, time, and individuals' security, and also has a high portion in the total travels in peak times. On the other hand, this planning has a direct relationship with the satisfaction degree of employers, and due to this point, planners are going to do it as well as possible. Current research studies the cases of the transportation system of Iranian Butia Steel Company's employers to provide a method for optimizing this system. In this research, the economic

productivity of the plan and the increasing satisfaction of employers are considered the goals of the research. In this research, implementing existing information of transportation systems, developing a mathematical model for locating stations, developing a routing model to determine optimum routes, and finally solving and assessing these models by the employers' information in a sample working shift of the company have been conducted.

Hosein Pour and Bagheri, (2020) inventory routing plan (IRP) is one kind of routing that determines existing strategies and transportation planning simultaneously. We introduce a green inventory routing with a heterogeneous fleet and concerning random demand in which we consider a united supplier and several retailers that the supplier requires to meet the demands of retailers. The problem has a comprehensive goal which is to minimize the costs of routing and the costs of inventory in; which the costs of routing include drivers' salary, fixed costs of vehicles, fuel, and the costs of CO2 emission that the costs of fuel and CO2 emission are determined by loads, speed and the type of vehicle. Two Stage Stochastic Optimization is considered, and the Two-objective problem is solved by the Epsilon Constraint method, and then the numerical example is solved, and the advantages of using the stochastic method are determined.

Etebari and Dashtian (2020) stated that the routing-inventory problem is a useful problem in the field of distributing goods. This problem is the result of integrating two classic problems. The first problem is related to routing, which determines the routes of vehicles' maneuvers between several locations. The next problem is inventory which plans and determines inventory policy according to the maintenance cost and shortage. One of the characteristics of this problem is its dynamics which indicates the intense related decisions to time, and it should be repeated several times according to horizon time. On the other hand, today, using vehicles with electronic fuel and hybrid vehicles has a special position in the green systems of distribution. In this research, we try to compose two above approaches; the problem of routing-inventory is developed by concerning hybrid fleet. In order to do this, first, the mathematical model of the problem of routing-inventory is presented by considering hybrid fleets, and then a large neighborhood search algorithm is used to solve this model on a real scale. GAMS software has been used to investigate the correctness of the presented mathematical model, and the results of the proposed algorithm are compared to the results of the exact method in order to evaluate the algorithm. Then the results of the meta-heuristic algorithm are presented and analyzed for the sample of produced problems. The reported results confirm the appropriate performance of the proposed algorithm. Finally, the Sensitivity analysis is implemented on the parameters of the problem.

Sadat Ghiasi and Etebari (2020) stated that one of the important problems in the management of the supply chain is the problem of routing vehicles and optimizing transportation, and its useful assessment leads to a significant reduction in the costs of distribution. In the current research, a model is proposed to solve the problem of routing heterogeneous vehicles according to the existing situations in some distribution companies concerning sending different kinds of goods to customers, including medical and consuming goods, which considers existing standards of distributions process by separating heterogeneous fleets and accordance with the type of distributing goods. The presented mathematical model in this paper is resulted from the process of distributing

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goods in Alborz Distribution Company (distributing company of medical and consuming goods). Moreover, using electronic vehicles is added to it in order to avoid increasing pollution. According to the NP-Hard problem of routing to solve the proposed model on a large scale, the meta-heuristic algorithm of simulated annealing (SA) has been used, and the Taguchi method has been applied to set the parameters of SA up. Then, numerical examples are investigated to show the validity of the mixed integer mathematical model and solving approach. Finally, the trend of changings function of assessing goals and influencing parameters on the management of network costs has been determined by sensitivity analyses on two parameters of the model.

HoseinZade Saljoghi (2020) stated that the obvious presence of different areas of engineering in the transportation field shows its importance as a lifeline. The importance of its other and current aspects is the concern about its environmental consequences. Meanwhile, the Biotechnology approach is lighting for using green vehicles with the ability to repletion of energy sources which makes the environment healthy. The environmental necessitate of using these vehicles, in the time of their comparability to fossil vehicles, is a problem that is solved based on the procedures of improving productivity and efficiency rather than depending on the capability of equipment. Also, this research has been conducted for appropriate routing with energy resources of these vehicles in order to cover the demands of services and continue such an operation and investigate the performance of the method by researchers and sometimes by sampling real cases. Correspondence with the optimized amounts and, of course, the excellence in the number of vehicles and increase in productivity are the consequences of this method.

Nosrati and Arshadi Khamse (2020) provided and solved the problem of integrated vehicles in the situation of the presence of substitute routs and as two-objective. This problem is the development of green vehicle problems. The function of the first goal is the minimization of the total costs of the system and, therefore, the reduction of fuel consumption and the emission of greenhouse gases. The function of the second goal is related to the optimization of the reliability of the whole system. The presence of substitute routes can lead to increasing the quality of responses to this problem. This model originated from a mixed integer nonlinear type. To solve this problem efficiently, the exact method, as well as the multi-objective meta-heuristic algorithm of simulated annealing (SA), has been used. Examples in different scales are constructed and compared to compare the results of these two solving methods. Obtained results show the acceptable ability of the proposed algorithm to solve this problem.

Mousa Zade et al., (2020) stated that the importance of home health care is increasing rapidly because the population of developed societies and even developing countries are getting older, and the number of hospitals, retirement homes, and the staff of medical departments is not increasing by the same amount. Therefore, home health care has become more important. Medical staffs provide concentrated service to different costumers in home health care. Since a combination of routing and timing is often required to provide service, the problems of its optimization are too complicated. In this paper, we try to provide a one-objective mathematical model for routing and timing of vehicles, collecting biological samples in home health care in order to minimize the costs of transportation concerning the special condition and tome of maintaining each biological sample. A case study in the real world has been used to assess the efficiency

of the mathematical model. The results show that the presented mathematical model can calculate the optimum response in small and medium scales in reasoning time duration.

Bastani Katoli and Noudehi (2020) stated that transportation has a significant position in economic systems such as production and service. The routing of vehicles for serviceability to customers is one of the important topics in the last decades and leads in increasing the efficiency and productivity of the transportation system. This problem helps in reducing the consumption of fuel and delivery time duration to the customers, which are important. The routing of vehicles has different types, and the form of the problem changes according to the different limitations. Since this problem is in the group of NP-hard problems, using approximate solutions is appropriate for them. One approximate algorithm is the algorithm of simulated annealing, which is efficient in this type of problem. In this paper, we investigated the function of the algorithm of simulated annealing in different models of vehicles' routing problems. Finally, it is suggested that the routing of vehicles can be solved by integrating the algorithm of simulated annealing with other algorithms.

Mardan, Soltanzadeh, and KamranRad (2019) in his research, has modeled a two-part supply chain including the number of warehouses as the center of distribution and a number of retailers as customers in the form of routing problems along with inventory routing; so that perishable products, which has usable life, are distributed to retailers from their warehouses. Also, expired products are ruinated at a cost. Retailors have limited capacity. The problem is modeled based on two-stage stochastic decision models with several scenarios. In the first stage, decisions about the stores are made, and in the second stage, they make decisions about routing. The transportation fleet is homogenous and has a determined capacity. A number of check problems are designed to investigate the influence of some parameters.

Ansari and AkhwanNiaki (2018) stated in their paper that the attempt to achieve sustainable management of the supply chain has new important logistics along with the traditional goal of minimizing costs. The managers and members of supply chains cannot make appropriate decisions because of the constraints and traditional assumptions and sometimes unreal about supply chains, such as the certainty of demands, not perishing goods, and…. Moreover, increasing concerns about the environment, increasing awareness of consumers about health and safety, demands for high-quality products, constraints in natural resources, and … make the problem of inventory management and routing more complicated and face more challenges. This research provides a model of green inventory management for perishable goods by the seller and routing under demand uncertainty considering the requirements of managers and decision-makers of supply chains for efficient models to make accurate and on-time decisions and existing complications in the problems of novel inventory management in which the routing is conducted in order to minimize the emission of Carbon pollution in two levels by assuming possible demands. In other words, the proposed model of this research introduces a mode according to the assumption of demand uncertainty in which forced costs, such as ordering costs, maintenance, the fuel consumption of vehicles, the salary of drivers, perishing of goods, and shortages, are minimized as well as meet possible demands appropriately.

Hamze Pour et al. (2017) investigated the routing-inventory problem in a three-level supply chain. These three levels are producer, wholesaler, and retailer. The problem of routing-inventory is aimed at minimizing the total costs of the system, including the costs of production, initiation, distribution, shortage, and the maintenance of inventory has been modeled in such a way that the fixed costs of initiation are considered stochastic. The products are delivered to wholesalers and retailers by the same vehicles with limited capacity. Also, production capacity and limited maintenance and shortage are assumed as allowed. The presented mathematical model is a scenario-based stochastic model. It means that the possibility of each scenario occurring is different from another scenario. The initiation cost is different in each scenario. We solved it with Lingo software.

Rabiei and Etebari (2017) stated that the concepts of integrated logistics systems and integrated decision-making become one of the most important aspects of the supply chain. In this paper, a routing model of green multi-warehouse vehicles has been studied, which was for multi-product perishable nutrition products in the distribution network of the cold supply chain, including potential distribution (storage area), costumers and transportation fleet. So, the problem has been formulated as an integer linear programming considering the perishability of products in the process of distribution and using refrigerator-equipped vehicles in order to maintain the freshness by depending on the fuel consumption on the load carried between nodes. In the proposed mathematical model, we try to make the problem closer to the real world by considering the constraints of capacity for warehouses and vehicles, associating the fuel consumption to load carried between nodes and the model has been tested by solving numerical examples in Gam's software.

Pilevar et al. (2017) in his article stated that one of the significant problems in logistics problems and the supply chain of perishable goods is the problem of routing and distribution networks which can reduce costs significantly. Different constraints such as the perishability of goods, expiration date of goods, the capacity of the warehouse, and service constraints to customers make the problem becoming a real-world problem. This paper is a mathematical model to solve dynamic capacitated routing-locating problems with simultaneous delivery and withdrawal, which provides constraints, including perishability of goods that exist in practice that can point out to the distribution system of drinks and foods. The aim of this paper is to choose an appropriate storage area and minimize the total costs of reopening facilities, fixed costs of vehicles, costs of routs of vehicles, assigning costumers to each storage area, and determining the sequence of service routes to costumers. At last, the presentation of a numerical example shows the efficiency and the goals of this article.

Seyyed Hosseini and Mohammadzadeh (2017) state that today, the importance of the management of the supply chain and optimum decision-making in decision-making levels in the chain cannot be ignored. On the other hand, sustainable development based on public awareness, governmental requirements and motivations, and sometimes economic savings, the management of supply chain in management literature has become more important recently. The problem of routing is the main part of distribution activities in industrial chains and has a significant background in research background. The problem of routing has a 50-year background and has developed much over time. On the other hand, a one-level traditional system for distributing goods in towns is in contrast with the requirements of sustainable development. In this research, the problem of two-level

routing has been modeled according to environmental goals along with economic goals as well as the social validity of costumers. The purpose of this research is to present a two-level routing model of the sustainable vehicle based on the novel models of fuel consumption which succeeded in achieving the goals of sustainable development and yet being practical in active industries in the field of practical distribution. The presented results and model in this paper can be used for food industries, automotive industries, and other related industries. Several numerical examples based on valid papers in the literature on the topic have been composed at the end of this paper and are solved to evaluate this model. The results of solving this model show the usability of this model and the rationality of considered assumptions in the two-level routing programming of the supply chain.

Mehranjoo and Behnamian (2017) state that transportation in producing-economic and service systems is important and assigns a significant part of the Gross National Products (GNP) of every country to itself. Because of it, researchers begin to improve routes, omit unnecessary travel or establish short substitute routes. Some topics have been developed in this regard, including traveling salesmen, vehicle routing problem (VRP), and …. Generally, the routing of facilities are assumed that there is a monopoly in the environment, and there is no attention to the impact of appropriate routing on competence. The routing problem is included in the NP-hand problem. This problem is going to act with mathematical and optimization models so that the traveled distance, total time of travel, the number of vehicles, payment penalty, and finally, the minimized function of transportation costs finally maximize the satisfaction of costumers. Due to the too-difficult structure of the VRP problem, exact algorithms have been rarely used for this problem, but heuristic and meta-heuristic algorithms have been successful in this field. For example, the column generation algorithm can be pointed to as a high-quality algorithm that has been used in this research. Column generation algorithm is the solving method of nonlinear programming for practical programs (with high demands) and rounding to an integer with satisfying results.

Zohrevand and BidhendiMohammadi (2017) presented a routing problem of heterogeneous vehicles with a time window considering the satisfaction of customers in a transitory warehousing system. A heterogeneous fleet of vehicles collects products from suppliers and, after integrating them in the transitory warehouse, delivers them to customers as soon as possible. Each customer has their own time window but tends to take service in a certain time interval of that time window. A mixed integer linear programming model has been presented for the problem, which tends to minimize fixed costs and variables of transportation and the earliness and tardiness of good delivery to costumers as well as appropriate timing of vehicles in order to increase customers' satisfaction. Also, a two-phase genetic meta-heuristic algorithm has been provided to solve this problem. Obtained results confirm that a higher level of customer satisfaction can be achieved by using a proposed approach in comparison with the classic model. Also, obtained numerical results show better performance and efficiency of the proposed algorithm in comparison with the classic genetic and simulated annealing algorithm.

Shen (2020) investigated a closed-loop supply chain network for the production and recovery of button cells under uncertainty. In conducted modeling, the environmental impacts of button cells in designing of supply chain network have been included. Since

there are many uncertainties in real, demand, cost and capacity are considered uncertain variables. Two multi-objective mixed integer programming models under uncertainty, i.e., the expected value model and the Chance-Constrained model, are created to study the influence of this uncertainty on the supply chain network. The purpose of the created model is to reduce numerous environmental impacts on the sum of costs as well as test the positive and negative aspects. A method based on assessing the life cycle to assess the environmental influences in the supply chain network has been presented. These two models can be converted to crisp models by uncertainty theory. In the end, numerical experiments are used to investigate the possibility of proposed models and methods.

Chernonog (2020) studied a two-class supply chain that includes a producer and a retailor and cooperates in the Stackelberg game, which determines the contracts of wholesaling costs for perishable products. Demands for a product depend on the purchasing price, investment in the advertisement, and time duration of not using a product before sale. Investment in advertisement can be conducted by the producer, retailer, or a sharing way. The parties of a policy use the amount of economic order in which the duration of the cycle has been determined by the leader of the supply chain inherently. The decision of parties about pricing, investing in the advertisement, and the duration of the cycle were modeled, and also they investigated how the balance of different forces between parties affected their decisions and other actions of the supply chain balance. They analyzed two cases especially: producer- leader and retailor-leader. For each one, the balance is achieved from demand (One in which the influence of price and advertising on demand are growing (the sum of influences) and the other in which they are the product of influences). The author stated that for a type of determining advertising investment (cooperative/non-cooperative) and determined duration of the cycle, the variable profit of each party is only determined according to their role (leader/follower) and not according to their identity (producer/retailer). This result is valid for formulating the function of advertising costs and demand. It is interesting that the type of advertising investment (cooperative/non-cooperative) depends on a series of decisions, whereas in balance, the cooperation of each party in advertising investment is only determined by its channel of force.

Ashtineh and Pishvaee (2019) stated that according to the current and growing trend of environmental concerns, transportation companies face internal and external forces, like other big sections consuming energy, to meet exact regulatory requirements. This study has been conducted to investigate the economic and environmental performance of substitute fuels in vehicle routing problems by measuring and determining the quantity of possible adverse impacts of emitted pollutants on human health and the quality of the ecosystem. Greenhouse gas emissions especially concerning pollutants (for example, NOx ، HC, and CO) and greenhouse gas emissions (for example, CO2, N2O) in production, distribution, and combustion phases, several mixed integer programming models were conducted based on well-analyzed to wheel and wheel to the tank. Beyond factors like distance, load, and speed, the proposed models consider the transmission gear ratio as the main influential factor in traveled distance and greenhouse gas emissions. Several numerical experiments were conducted to investigate the influences in the type of fuel and selecting gear and the intense of pollutants. The results show that although net biodiesel combustion has a negative effect on air quality, more analysis according to the total activities of the fuel chain leads to producing and consuming the product but shows

a reduction of 37% in greenhouse gas production with normal diesel based on measures equal to CO2.

Bottani et al. (2018) presented routing & locating (R&L) to design reverse logistics channels for food wastes according to the produced wastes in the retailing stage of the food supply chain (FSC). This model is built in Microsoft excel with its application in the Emilia-Romagna region of Italy, which is assessed as a research site for finding substitute ways of food recycling rather than destroying them in landfills. Multiple analyses are conducted by using this model to find some findings related to economic profitability creating a reverse logistics channel for food waste recycling in the target region and leading them to substitute usages. As there is no study that pays attention to investigating the problem of food waste disposal in Italy, this research is expected to show this case in addition to the details of the literature.

Rivera et al., (2016) conducted research in which they studied the problem of multi-travel routing-locating of collective capacities in single-vehicle mode. A vehicle can travel many successful travels to cover a set of under-influence regions and minimize the total time crisis of arriving vehicles by using logistics in a crisis time in this problem. They used two mixed numerical programming with 20 sites in their model, and then considered an exact algorithm for larger cases in the mode of limited resources in the problem of the shortest time between two nodes. The results showed that this problem could be solved by the Bellman-Ford algorithm.

Song and Ko (2016) conducted their research in this field and concluded that: they investigated the problem of transportation vehicle routing, including two types of public transportation vehicles with the refrigerator for multiple perishable food delivery. Also, they assumed that the place and the volume of demand for ordering products are determined for every costumer. However, the maximum capacity of delivery time and the number of both types of vehicles has been determined before. According to their characteristic, a non-linear model and a meta-heuristic algorithm were provided to increase customer satisfaction which has been depend on the freshness of delivered products.

Soysal (2016) conducted research in which they considered transferring the management of a sustainable supply chain as one of the main goals of logistics in addition to minimizing traditional costs of the supply chain, reducing wasting foods and environmental impacts on the supply chain. The traditional costs of the supply chain included the fixed cost of distribution between nodes, warehousing unlimited duration, and certain demands used in this inventory routing problem.

Ren et al. (2016) conducted a research that concluded: they conducted their research according to the optimum approach of robust in routing problems which we are facing daily maintenance problems of road. They considered uncertainty in service time. Then they solved their problem by using the branch and cut method. Calculating results analyzed robust solutions and their performance by Monte Carlo simulation. Analyzing observations created a management attitude to make decisions and seal appropriate routing strategies.

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Research Methodology

A supply chain can be introduced as a set of activities of different facilities in order to prepare materials and goods, produce products, transfer between different sections and distribute the final product between consumers. In addition, the management of the supply chain is the management of all considerations of different sections in the supply chain, like moving and substituting raw materials and final products, along with transportation decisions. Using this concept has significant competitive advantages for all participants in the supply chain. Designing a supply chain network provides strategic decisions which have an important role in the performance of the supply chain and its competitive advantages, as well as other decisions at an operational and tactical level of the supply chain over time. Choosing appropriate facilities from potential places, along with determining the number and their capacity, are the most important considerations and decisions in designing a supply chain network. These decisions are the most important components in the management of the supply chain because any kind of small and huge change in such an important and vital decision in each network affects lower levels directly or indirectly and therefore creates many costs in the whole chain. So, logistics is the process of strategic management, purchasing, moving, and restoring materials, parts, and final inventory and related information flows through its marketing organizations and channels through which current and future profitability maximize by doing optimized orders. Basically, logistics is the orientation and framework of programming, which searches for a united program for the flow of products and information through business. The management of the supply chain is built beyond this framework and seeks to achieve a link and coordination between the processes of other sections, such as suppliers and customers, and the organization itself. In this paper, a supply chain will be introduced and provided based on multi-objective modeling in the fields of financial risk, purchasing cost, transportation, maintenance, and lost sales and establishing warehouse and routing in an agile supply chain for perishable goods and at the end, a four-level model is designed.

Stable and Fuzzy Design of Supply Chain

In this paper, a robust (uncertainty in demand) and fuzzy (cost parameters) mathematical model will be presented according to existing real space in problems related to the supply chain and uncertainty in this space.

Benders Solving Approach

According to conducted investigations in the literature reviews of most researches, heuristic and meta-heuristic algorithms were used because the supply chain models were NP-HARD which is inefficient due to the approximation of optimal responses in this field. On the one hand, the approach of the Benders algorithm will be used to solve the mathematical model to improve the time duration of solving the model as well as provide exact responses.

Robust Mathematical Model

In the recent four decades, many studies provided methods to enter risk in stochastic models. A solution is robust in that the response of the model doesn't change by creating small changes in its basic data. Robust optimization integrates target function to input data based on scenario base and includes two separate adverbs: structural adverb and control adverb. Structural adverbs are formulated by using linear programming, and their input data has no disturbance. At the same time, control adverbs are considered auxiliary adverbs which deal with uncertain data. Stochastic Optimization is answered by considering the distribution function for the noise variables, which optimizes the expected amount or other criteria like this. Robust optimization usually has no assumption about the distribution function of noise variables. It searches for a response that has acceptable performance for all modes of noise variable. Typically obtained responses are too conservative (worst case). Meanwhile, Bertsimas and Sim brought an evolution in robust optimization by providing a model that is conservative and can be arranged, and the robust peer of a linear problem is a linear programing problem. This model is able to be applied to optimization problems with discrete variables (Bertsimas et al., 2004). Robust optimization is included among approaches that are so efficient in situations in which there are uncertainties. Robust optimization was introduced by Soyster in 1973. The presented model by Soyster performs too conservatively, and it is the most pessimistic approach. In the last two decades, they attempted too much to provide appropriate controllable robust models to solve different types of optimizing problems with uncertain data. These models are less conservative and provide better responses.

Problems are usually solved presupposing that the data is certain in advance in mathematical programming, while most of the data are uncertain in the real world. The main presupposition of mathematical programming is the development of a model based on explicitly determined data equal to a nominal amount. However, in this kind of model, the effect of data uncertainty has no effect on the quality and feasibility of the responses. Therefore, in real-world problems, a large number of constraints may be contravened by changing one of the data, and obtained response may be non-optimal or even impossible. According to this discussion, the main question of building a response for the problem that is resistant to this uncertainty of the data, so-called these responses are robust, and this type of optimization is called robust optimization (Bertsimas et al., 2004).

The primary idea in robust optimization is considering the worst scenario possible and optimization based on the worst scenario. For instance, assume that the coefficient can change in one of the constraints. In robust optimization, the worst situation which may occur for a constraint is considered according to the change in coefficient, and optimization is conducted based on it. The most important shortage of this method is its conservative performance. This method may not have much practical application, but it will be very useful as a tool for decision-making. The optimization word has its especial concept in mathematics, and it is used in different fields, including energy in Iran. Energy consumption optimization for a process can be conducted locally or comprehensively for a system that includes several processes. Since this paper is in the main branch of the perishable goods supply chain, which will be developed based on an agile supply chain and has built the new problem of the agility model of perishable products supply chain focusing on the delay time of order, so the problem hypotheses are:

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1. Supply chain problem is a multi-commodity.

2. Modelling is multi-period.

3. Costumers demand has the uncertainty of robust.

4. Cost parameters have fuzzy trapezoidal uncertainty.

5. Vehicles are homogeneous.

6. Vehicles have limited capacity.

7. The number of vehicles is limited.

8. Studying goods are perishable.

9. Lost sale is allowed in every period.

10. The inventory of products in the warehouse of the company is not allowed.

The following symbols are used to develop a mathematical model.

Indices:

$i=1,2,\cdots,I$	production locations
$j=1,2,\cdots, J$	candidate points and distribution location constant
$k=1,2,\cdots, K$	customers' location
$l=1,2,\cdots, L$	candidate points and recycle location constant
$t=1,.., t',..,T$	time periods
$o=1,2,\cdots, O$	recycle customers' location

Parameters:

f_i	fixed costs of establishing distribution center j
f_l	fixed costs of establishing recycle center l
Cx_{ij}	transportation cost from producer i to distributor j
P_i	sale price of every unit of product i
Cs_{ik}	transportation cost from producer i to costumer k
Cu_{jk}	transportation cost from distributer j to costumer k

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Ce_{kl} transportation cost from producer k to recycle center l

Cq_{jl} transportation cost from distributer j to recycle center l

Cv_{il} transportation cost from producer i to recycle center l

Cf_{lo} transportation cost from recycling center l to compost market

Ch_t maintaining the cost of the product by the distributor in period t

Cp_t processing and packing cost by the distributor in period t

Cr_t recycle cost by recycling center in period t

Cp' advertisement cost and producing product by the producer

d_{kt} the demand of costumer k in period t

λc_{it} maximum capacity of producer i in period t

λh_j maintenance capacity of distributer j in period t

λr_l production capacity and storage of recycling center l

α_t waste percentage of produced products in period t

θ_t waste percentage of stored products of the costumer in period t

β_t waste percentage of the stored product of the distributor in period t

d'_{ot} reprocessed product demand (compost) by costumer of compost o in period t

ρ financial risk for response in forward flows

ρ-1 financial risk (importance) for response in recycling flows of perishable products

φ conversion factor of waste product to processed product

M extra large positive number

Decision variables:

X_{ijt} The amount of product which is sent from producer i to distributer j in period t

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λ_{it}	Production amount by a producer I in period t
S_{ikt}	The amount of product which is sent from producer i to costumer k in period t
U_{jkt}	The amount of product which is sent from distributer j to costumer k in period t
E_{klt}	The amount of waste (perished) product which is sent from costumer k to recycle center l in period t
Q_{jlt}	The amount of waste (perished) product which is sent from distributer j to recycle center l in period t
V_{ilt}	The amount of waste (perished) product which is sent from producer i to recycle center l in period t
Ih_{jt}	The amount of processed product which is kept from the warehouse of distributer j in period t
$W_j \begin{cases} 1 \\ 0 \end{cases}$	If distributing center is established in candidate place j, otherwise it is zero.
$Y_l \begin{cases} 1 \\ 0 \end{cases}$	If the recycling center is established in candidate place l, otherwise it is zero.
F_{lot}	The amount of compost which is sent from recycling center l to compost market o in period t.

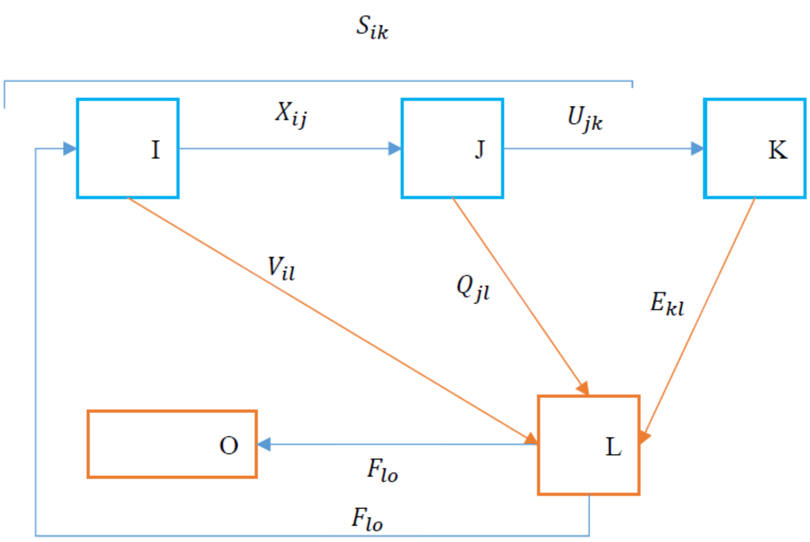

Figure 1. A scheme of the proposed network along with decision variables.

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Proposed Model

According to the definition of the problem and considering the assumptions, the mathematical model is designed to maximize the obtained profit from selling products detracted from the costs of the supply chain, including transportation costs, the costs of constructing potential places of distributing center, the costs of maintenance inventory and production cost and risk and processing and minimizing financial risk.

Target functions:

This model has included two target functions maximizing profit and minimizing financial risk.

$$Max\ z = z - z1 - z2 - z3 - z4$$

$$z = \sum_{i=1} \sum_{j=1} \sum_{t=1} x_{ijt} * p_i + \sum_{i=1} \sum_{k=1} \sum_{t=1} S_{ikt} * p_i \tag{1}$$

$$z_1 = \sum_{j=1}^{J} f_j \times W_j + \sum_{l=1}^{L} f_l \times Y_l \tag{2}$$

$$\begin{aligned} z_2 = & \sum_{i=1}^{I}\sum_{j=1}^{J}\sum_{t=1}^{t'} Cx_{ij} \times X_{ijt} + \sum_{j=1}^{J}\sum_{k=1}^{K}\sum_{t=1}^{T} Cu_{jk} \times U_{jkt} + \sum_{i=1}^{I}\sum_{k=1}^{k}\sum_{t=1}^{t'} Cs_{ik} \times S_{ikt} \\ & + \sum_{i=1}^{I}\sum_{l=1}^{L}\sum_{t=1}^{t'} Cv_{il} \times V_{ilt} + \sum_{j=1}^{J}\sum_{l=1}^{L}\sum_{t=1}^{T} Cq_{jl} \times Q_{jlt} + \sum_{k=1}^{K}\sum_{l=1}^{L}\sum_{t=1}^{T} Ce_{kl} \times E_{klt} \\ & + \sum_{l=1}^{L}\sum_{t=1}^{T}\sum_{o=1}^{O} Cf_{lt} \times F_{lot} \end{aligned} \tag{3}$$

$$z_3 = \sum_{j=1}^{J}\sum_{t=1}^{T} Ih_{jt} * Ch_t \tag{4}$$

$$z_4 = \sum_{i=1}^{I}\sum_{j=1}^{J}\sum_{t=1}^{T} X_{ijt} \times Cp_t + \sum_{l=1}^{L}\sum_{t=1}^{T}\sum_{o=1}^{O} F_{lot} \times Cr_t + \sum_{i=1}^{I}\sum_{t=1}^{t'} \lambda_{it} \times Cp' \tag{5}$$

Equation (1-3) is the minimization of costs as the sum of four kinds of presented costs in equations (2-3) to (3-5). Equations (2-3) is included the fixed costs of establishment and recycling. It should be mentioned that centers of distribution and recycling can be both existing points and potential points that we consider the establishment costs of existed points zero in parameters rather than adding indices. In equations (3-3), transportation costs, including forwarding costs and perishable recycling products, and in equations (3-4), maintenance costs of processed products are included. In equation (5-3),

operational costs include processing costs and packing and advertising, and reprocessing costs.

$$Min\ Z = \rho \times \left(\sum_i \sum_j \sum_k s_{ikt} + \sum_t \sum_j \sum_k u_{jkt} \right) \Big/ \sum_t \sum_k d_{kt} + (1 - \rho) \times \sum_t \sum_l \sum_o f_{lot} \Big/ \sum_t \sum_o d_{ot} \qquad (6)$$

Equation (6) describes the second objective function, which is the minimization of the financial risk level. The response is divided into two parts of the customers of main products and the customers of reprocessed products that the responsiveness of each section is equal to dividing the amount of entered products to the target customer market by the amount of each market's demand.

Limitations:

There are 12 limitations in this mathematical model, as follows:

$$\lambda_{it} \times (1 - \alpha_t) = \sum_{j=1}^{J} X_{ijt} + \sum_{k=1}^{K} S_{ikt} \qquad \forall i \in I, \forall t \in t' \qquad (7)$$

Equation (7) indicates the amount of production by producers by deducting equal to the amount of transferring from producers to distributers and target market.

$$\sum_{i=1}^{I} \sum_{t=1}^{T=t'} X_{ijt} \leq M \times W_j \qquad \forall j \in J \qquad (8)$$

Also, equation (8) is the limitation related to equation (7-3) which emphasizes that sending load to potential distributers occurs if that place establishes.

$$\lambda_{it} \leq \lambda c_{it} \qquad (9)$$

Equation (9) indicates that the amount of producing a product by smaller producers is equal to their maximum capacity.

$$Ih_{j(t-1)} + \sum_{i=1}^{I} X_{ijt} = Ih_{jt} + \sum_{k=1}^{K} U_{jkt} + \sum_{l=1}^{L} Q_{jlt} \qquad \forall j \in J, \forall t \in T \qquad (10)$$

Equation (10) shows that the warehouse inventory of distributers in every period is equal to the inventory of previous inventory deducted by the wastes of the previous period in addition to new products entered into the warehouse and deducted by exited products from the warehouse to processing and packing lines.

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$$Ih_{jt} \leq \lambda h_j \qquad \forall j \in J, \forall t \in T \tag{11}$$

Equation (11) indicates the fact that the maximum inventory of a smaller distributor warehouse is equal to the capacity of the warehouse.

$$\sum_{j=1}^{J} U_{jkt} + \sum_{i=1}^{I} S_{ikt} \leq d_{kt} \qquad \forall k \in K, \forall t \in T \tag{12}$$

Equation (12) means that market demand in each period is more than or equal to entered products from producers and distributers.

$$\sum_{l=1}^{L} V_{ilt} \leq \alpha_t \times \lambda_{it} \qquad \forall i \in I, \forall t \in t' \tag{13}$$

$$\sum_{t=1}^{T=t'} \sum_{i=1}^{I} V_{ilt} \leq M \times Y_l \qquad \forall l \in L \tag{14}$$

$$\sum_{l=1}^{L} Q_{jlt} \leq \beta_t \times Ih_{j(t-1)} \qquad \forall j \in J, \forall t \in T \tag{15}$$

$$\sum_{t=1}^{T} \sum_{j=1}^{J} Q_{jlt} \leq M \times Y_l \qquad \forall l \in L \tag{16}$$

$$\sum_{l=1}^{L} E_{klt} \leq \theta_t \times d_{kt} \qquad \forall k \in K, \forall t \in T \tag{17}$$

$$\sum_{t=1}^{T} \sum_{k=1}^{K} E_{klt} \leq M \times Y_l \qquad \forall l \in L \tag{18}$$

Equations (13) and (18) show that the amounts of waste in every section appear for the flow of perishable products in the case of establishing recycle centers.

$$\left(\sum_{i=1}^{I} V_{ilt} + \sum_{j=1}^{J} Q_{ilt} + \sum_{k=1}^{K} E_{ilt} \right) \times \varphi = \sum_{o=1}^{O} F_{lot} \qquad \forall l \in L, \forall t \in T \tag{19}$$

Equation (19) shows that the total sum of sending waste to recycle centers from producers, distributer, and customers multiplied by the transfer rate of waste products to compost is equal to the total sending recycled to the markets and costumers of compost.

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$$\sum_{o=1}^{O} F_{lot} \leq \lambda r_l \qquad \forall l \in L, \forall t \in T \tag{20}$$

Equation (20) indicates that the total compost sent to the market and costumers of compost is less than or equal to the production capacity of the recycling center.

$$\sum_{l=1}^{L} F_{lot} \leq d'_{ot} \qquad \forall o \in O, t \in T \tag{21}$$

Equation (21) indicates that the total compost sent to the market and costumers of compost is less than or equal to the demand of compost costumer.

$$Y_l \ , W_j \in \{0,1\} \qquad \forall l \in L \ , \forall j \in J \tag{22}$$

$$X_{ijt} \ , S_{ikt}, U_{jkt}, V_{ilt}, Q_{jlt}, E_{klt}, F_{lot} \geq 0 \quad \forall o \in O, \forall i \in I, \forall j \in J, \forall k \in K, \forall t \in T, \forall l \in L \tag{23}$$

$$Ih_{jt} \geq 0 \qquad \forall j \in J, \forall t \in T \tag{24}$$

Equations (22) to (24) indicate sign variables or their being one or zero variable and being positiveness.

Considering Uncertainty

As we know, investigating the reason for uncertainty in the components of the supply chain in optimistic, medium, and pessimistic modes to analyze the opinions of experts on real environment situation in the supply chain since the theoretical dimensions of the topic has an approach toward the amounts of the fuzzy problem; therefore, the environmental situation of the chance-constraint fuzzy algorithm will be used. On the other hand, On the other hand, according to the accuracy of comment evaluation in trapezoidal fuzzy rather than triangular fuzzy possibilistic-robust, therefore this theory has been used.

In this section, a fuzzy possibilistic-robust programming model with constraint chance is presented for the research problem in order to deal with uncertainty in the parameter of the amounts of demand (Dkt). The used fuzzy possibilistic-robust programming model in this research is a common method that depends on mathematical concepts such as the expected value of fuzzy numbers and possible measurements (POS) and necessity measurements and allows decision makers to control the level of satisfying conservativeness of constraints and also, this supports the different forms of fuzzy as triangular and trapezoidal completely. First, consider mathematical programming problem for further introduction and for simplification:

$$Min\ Z = f.y + \tilde{c}.x \tag{25}$$

$$A.x \geq \tilde{d}$$

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$$B.x = 0$$

$$s.x \leq N.y$$

Assume that f is the vector of certain parameters and c is the vector of uncertain parameters of the problem. Also, x is the vector of continuous variables, and y is the vector of zero and one variables. Also, A, d, B, and N is the technical coefficient of the problem. Assume that considering uncertain parameters (c and d) –according to this fact that the demand of consumer is considered as uncertain- as trapezoidal fuzzy numbers (θ= θ1, θ2, θ3, θ4), the above model can be written as:

$$Min\ E[Z] \tag{26}$$

$$Pos\{A.x \geq \tilde{d}\} \geq \alpha_m \tag{27}$$

$$B.x = 0 \tag{28}$$

$$s.x \leq N.y \tag{29}$$

$$\begin{aligned} &0.5 \leq \alpha_m \leq 1 \\ &x \geq 0 \\ &y \in \{0,1\} \end{aligned} \quad (30$$

According to the research of Inuiguchi and Ramık (2000), the above model can be written as follows:

$$Min\ Z = f.y + \left(\frac{c_{(1)} + c_{(2)} + c_{(3)} + c_{(4)}}{4}\right).x \tag{31}$$

$$A.x \geq (1 - \alpha_m).d_{(1)} + \alpha_m.d_{(2)} \qquad \forall m \tag{32}$$

$$B.x = 0 \tag{33}$$

$$s.x \leq N.y \tag{34}$$

$$0.5 \leq \alpha_m \leq 1$$

$$x \geq 0 \qquad \forall m \tag{35}$$

$$y \in \{0,1\}$$

Therefore, the first target function of the possibilistic-robust programming model of the research problem is presented as follows.

The modified target function is:

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$$Min\ Z = \rho \times \left(\sum_i \sum_j \sum_k s_{ikt} + \sum_t \sum_j \sum_k u_{jkt}\right) \Big/ \sum_t \sum_k \left(\frac{d_{kt(1)} + d_{kt(2)} + d_{kt(3)} +}{4}\right. + (1-\rho) \times \sum_t \sum_l \sum_o f_{lot} \Big/ \sum_t \sum_o d_{ot} \tag{36}$$

$$\sum_i s_{ikt} + \sum_j u_{jkt} \leq (1-\alpha) d_{kt(1)} + \alpha d_{kt(2)} \qquad \forall\, k, t$$
$$\sum_i s_{ikt} + \sum_j u_{jkt} \geq (1-\alpha) d_{kt(4)} + \alpha d_{kt(3)} \qquad \forall\, k, t \tag{37}$$

Validation with Constraint-Epsilon

The empowered constraint-epsilon method provides efficient, optimized responses of Pareto. One of the target functions is considered the main target function in the constraint-epsilon method to optimize, while the other target function is considered a constraint in the model. The empowered constraint-epsilon model can be presented as follow:

$$Min/Max(f_1(x) + \vartheta * \left(\frac{s_2}{r_2} + \frac{s_3}{r_3} + \cdots + \frac{s_i}{r_i} \ldots + \frac{s_n}{r_n}\right))$$

St:

$$f_2(x) - s_2 = \varepsilon_2$$

$$f_3(x) - s_3 = \varepsilon_3$$

$$\ldots.$$

$$i \in [2, n]$$

$$s_i \in R^+$$

The optimized solutions of Pareto are obtained based on the above equation in which ri is the domain of the target function of I, ϑ is a very small number between .001 to .000001, and Si is a non-negative surplus variable. First, the measurement of NISfi (the worst measurement) and PISFI (the best measurement) is obtained for each target function, then the measurement of the domain of target function I is calculated as follows:

$$r_i = PIS_{fi} - NIS_{fi}$$

After that, ri is divided into equal intervals of li. Then li+1 points are obtained by which the equation under epsilons is calculated based on a Grid point. In this method, the model should be solved for all obtained epsilons in which η numbers of Grid points have been obtained according to the equation.

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$$\varepsilon_i^{\eta} = NIS_{fi} + \frac{r_i}{l_i} * \eta$$

Validation of Accuracy based on Empowered Constraint-Epsilon

To validate the accuracy and credit of the proposed model, a problem with a smaller dimension is solved by GAMS software. Then the provided mathematical model is solved by GAMS software which is operation research software, and we assess the proposed model by solving a numerical example.

One of the accurate methods to obtain Pareto solutions is using the constrain-epsilon method. The main advantage of this method is the multi-objective optimization of its application for non-convex solving spaces rather than other methods because methods, including a composition by weight targets, lose their functionality. Calculating the time of an algorithm is among the important characteristics of every algorithm for assessing it since one of the main weaknesses of algorithms based on exact searches, such as constraint-epsilon, is its high calculating time; it is obvious that using a meta-heuristic algorithm will lead in intense reduction of calculating time.

We always attempt to optimize one of the goals in this method if we introduce the greatest accepted extent for other goals in the dominant constraints, which will be for a two-objective mathematical representation of this problem as:

$$\text{Min } f_1(x) \tag{38}$$

$$\text{Subject to } f_2(x) \le \varepsilon_2, f_3(x) \le \varepsilon_3, \ldots, f_p(x) \le \varepsilon_p, \; x \in S$$

The Pareto edge of the problem will be obtained by changing the right side of new constraints Ɛs. One of the main problems of constraint-epsilon is the high volumes of calculations because for every target function becoming a constraint (as the number of p-1), different amounts of ε_i should be tested. One of the most common approaches to implementing constraint-epsilon is that first, the maximum and minimum amounts of all target functions are calculated without considering target functions and in $x \in S$ space. The interval one related to every target function is calculated by obtained amounts from the previous phase. If maximum and minimum amounts of target functions are called $f_i^{\max}$, and $f_i^{\min}$ respectively, then their interval of them is calculated as follows:

(39)

$r_i = f_i^{\max} - f_i^{\min}$ Interval rt is divided by interval qi. Then ε_i, the different amount can be obtained equal to $q_i + 1$ those calculated as follow:

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$$\varepsilon_i^k = f_i^{\max} - \frac{r_i}{q_i} \times k \qquad k = 0,1,\dots,q_i \tag{40}$$

In the above equation, k shows the new point related to ε_i. By the constraint-epsilon method, the multi-objective optimization problem can be converted to $\prod_{i=2}^{p}(q_i+1)$ numbers of one-objective optimization sub-problem. Each sub-problem has the space response of S according to this fact that the unequal related to target functions $f_2,\dots,f_p$ will be more limited. Each sub-problem results in a candidate response for the intended multi-objective optimization problem of the so-called optimized Pareto frontier. Sometimes, some of the sub-problems create an unjustified space of 1. Finally, after obtaining an optimized Pareto frontier, decision maker two can choose the most appropriate response from his/her point of view and uses it.

In this paper, we seek to design a five-level closed-loop network including producers, distributers, costumers, recycle centers, and the customers of recycling.

In order to do this, 12 problems are considered in different dimensions in this paper; this data have shown in table 1.

Table 1. Problems in different dimensions

Number of problems	I	J	K	L	M
1	3	4	3	4	2
2	5	7	5	7	4
3	7	10	7	10	6
4	9	13	9	13	8
5	15	22	15	22	14
6	17	25	17	25	16
7	19	28	19	28	18
8	25	37	25	37	24
9	35	52	35	52	34
10	37	55	37	55	36
11	39	58	39	58	38
12	41	61	41	61	40

Sub-problem 1 is the case study of this research which has been used to evaluate the proposed model and methods. Chosen towns for each place in this problem are in table 2. Also, used transportation costs between towns for all problems have been obtained from table 3.

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Table 2. Chosen towns for each place

O	L	k	j	I
City 1	City 3	City 7	City 10	City 14
City 2	City 4	City 8	City 11	City 15
	City 5	City 9	City 12	City 16
	City 6		City 13	

Table 3. Transportation cost between towns (dollar/kilometer)

	town 1	town 2	town 3	town 4	town 5	town 6	Town7	town 8	town 9	town10	town 11	town 12	town 13	town 14	town15	town16
town1	3.7	4.9	9.0	12.5	12.8	19.4	20.8	17.8	15.2	20.5	19.2	21.3	30.4	34.1	43.7	47.7
town 2	4.9	3.7	5.3	8.7	9.0	17.3	17.3	30.1	11.4	17.0	17.1	17.8	23.8	30.7	40.3	44.2
town 3	9.0	5.3	3.7	4.6	4.9	13.1	13.8	11.4	8.0	9.5	13.0	17.2	11.8	26.9	36.5	39.8
town 4	12.5	8.7	4.6	3.7	7.1	13.1	14.5	7.0	8.5	9.9	13.5	18.3	13.1	24.7	34.3	40.9
town 5	12.8	9.0	4.9	7.1	3.7	9.4	12.3	8.0	8.2	9.7	12.8	17.3	12.6	23.5	33.4	40.4
town 6	19.4	17.3	13.1	13.1	9.4	3.7	4.4	16.6	13.1	18.1	18.1	19.1	18.7	31.6	41.2	45.1
town 7	20.8	17.3	13.8	14.5	12.3	4.4	3.7	17.8	16.4	20.2	19.7	22.0	21.7	33.8	42.5	46.4
town 8	17.8	30.1	11.4	7.0	8.0	16.6	17.8	3.7	4.6	3.9	7.8	5.9	5.6	19.4	29.0	32.9
town 9	15.2	11.4	8.0	8.5	8.2	13.1	16.4	4.6	3.7	7.3	6.1	8.9	9.0	20.6	30.1	34.1
town 10	20.5	17.0	9.5	9.9	9.7	18.1	20.2	3.9	7.3	3.7	2.9	3.9	4.1	18.1	27.4	28.2
town 11	19.2	17.1	13.0	13.5	12.8	18.1	19.7	7.8	6.1	2.9	3.7	5.6	5.8	17.4	25.7	29.6
town 12	21.3	17.8	17.2	18.3	17.3	19.1	22.0	5.9	8.9	3.9	5.6	3.7	3.2	15.2	18.3	27.9
town 13	30.4	23.8	11.8	13.1	12.6	18.7	21.7	5.6	9.0	4.1	5.8	3.2	3.7	13.3	20.2	29.1
town 14	34.1	30.7	26.9	24.7	23.5	31.6	33.8	19.4	20.6	18.1	17.4	15.2	13.3	3.7	10.9	15.2
town 15	43.7	40.3	36.5	34.3	33.4	41.2	42.5	29.0	30.1	27.4	25.7	18.3	20.2	10.9	3.7	5.4
town 16	47.7	44.2	39.8	40.9	40.4	45.1	46.4	32.9	34.1	28.2	29.6	27.9	29.1	15.2	5.4	3.7

Also, other parameters of the model form the first problem are presented in table 4. In addition to these amounts, φ, p and M are considered equal to 1.1 and 0.6, and 1015 respectively. Also, cp' is assumed to be equal to 170 and fj is equal to 0, 0, 114290, 180000, and fl is equal to 0, 0, 14285, 20000 in this problem.

Table 4. Parameters related to the first problem

Parameter	Indices	t_1	t_2	t_3	t_4	t_5	t_6	t_7	t_8
ch_t	-	58	58	60	63	63	66	68	72
cp_t	-	86	89	89	91	94	94	100	103
cr_t	-	86	86	100	100	100	115	129	137
d_{kt}	k_1	3	4	3	7	8	5	10	8
	k_2	3	3.5	3.8	6	7.5	4.8	4.8	6.5
	k_3	3	3.2	3.5	5	5.5	4	10	5
λc_{it}	i_1	30	20	70	0	0	0	0	0

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Parameter	Indices	t_1	t_2	t_3	t_4	t_5	t_6	t_7	t_8
	i_2	90	11	45	0	0	0	0	0
	i_3	95	50	80	0	0	0	0	0
λh_{jt}	j_1	10	10	10	0	0	0	0	0
	j_2	20	20	20	0	0	0	0	0
	j_3	10	10	10	0	0	0	0	0
	j_4	30	30	30	0	0	0	0	0
λr_{lt}	l_1	4	4	5	4.3	4.8	5.3	5.2	10
	l_2	5.3	4	4.9	5.3	5.7	4.1	6.9	7.1
	l_3	8.3	4	4.6	7.3	4.5	6.3	4.7	10
	l_4	6.41	4.35	5	6	5.5	10	9.2	8.31
α_t	-	0.1	0.12	0.15	0	0	0	0	0
β_t	-	0.02	0.02	0.03	0.03	0.035	0.04	0.045	0.05
θ_t	-	0.02	0.03	0.04	0.045	0.045	0.048	0.05	0.05
d'_{ot}	o_1	10	20	18	15	14	6	7.9	8.5
	o_2	15	20	16	15.3	14.36	20	6.78	7

After introducing data related to the first problem, the remaining parameters of the model for the other problems are presented in table 5.

Table 5. The remaining parameters of the model

Unit	Amount	Parameter
period) month(	۸	T
period) month(	3	t'
percentage	[0.1, 0.12, 0.15, 0, 0, 0, 0, 0]	At
percentage	[0.02, 0.02, 0.03, 0.03, 0.035, 0.04, 0.045, 0.05]	Bt
percentage	[0.02, 0.03, 0.04, 0.045, 0.045, 0.048, 0.05, 0.05]	Θt
percentage	1.1	Φ
percentage	0.6	Ρ
percentage	0.4	۱-ρ
ton	Uniform ~ [30, 100]	Λcit
dollar	Uniform ~ [114290, 185715]	Fj
dollar	Uniform ~ [14285, 22855]	Fl
Dollar/ton	[58, 58, 60, 63, 63, 66, 68, 72]	Cht
Dollar/ton	[86, 89, 89, 91, 94, 94, 100, 103]	Cpt
Dollar/ton	[86, 86, 100, 100, 100, 115, 129, 137]	Crt
Dollar/ton	Uniform ~ [143, 172]	cp'
ton	Uniform ~ [3, 10]	Dkt
ton	10 or 20 or 30	Λhj
ton	Uniform ~ [4, 10]	Λrt
ton	Uniform ~ [5, 20]	d'ot
Billion RIals	Uniform ~ [10, 20]	ben_i
percentage	Uniform ~ [15, 35]	off_{ik}

Unit	Amount	Parameter
percentage	Uniform ~ [45, 60]	sal_{ik}
Billion Rials	Uniform ~ [3, 5]	otf_{ilt}

Validation with Constraint-Epsilon

The empowered constraint-epsilon method provides efficient, optimized responses of Pareto. One of the target functions is considered the main target function in the constraint-epsilon method to optimize, while the other target function is considered a constraint in the model. The empowered constraint-epsilon model can be presented as follow:

$$(41)\ Min/Max(f_1(x) + \vartheta * (\frac{s_2}{r_2} + \frac{s_3}{r_3} + \cdots + \frac{s_i}{r_i} \ldots + \frac{s_n}{r_n}))$$

St:

$$f_2(x) - s_2 = \varepsilon_2$$

$$f_3(x) - s_3 = \varepsilon_3$$

$$i \in [2, n]$$

$$s_i \in R^+$$

The optimized solutions of Pareto are obtained based on the above equation in which ri is the domain of the target function of I, ϑ is a very small number between .001 to .000001, and Si is a non-negative surplus variable. First, the measurement of NISfi (the worst measurement) and PISFI (the best measurement) is obtained for each target function, then the measurement of the domain of target function I is calculated as follows:

$$r_i = PIS_{fi} - NIS_{fi}$$

After that, ri is divided into equal intervals of li. Then li+1 points are obtained by which the equation under epsilons is calculated based on a Grid point. In this method, the model should be solved for all obtained epsilons in which η numbers of Grid points have been obtained according to the equation.

$$\varepsilon_i^{\eta} = NIS_{fi} + \frac{r_i}{l_i} * \eta$$

Now, after programming in GAMS, first, the obtained results are presented as follows. At last, the following amounts are obtained for every variable:

r2	18848
Li	10
NIS2	52
PISF2	18900
ϴ	0.0001

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Then, the number of epsilons is calculated by the following equation.

$$\varepsilon_i^{\eta} = NIS_{fi} + \frac{r_i}{l_i} * \eta \qquad (43)$$

Finally, the empowered epsilon model was solved by using GAMS software for each epsilon. The set of responses of optimized Pareto are as follows as table 6.

Tablev6. Set of responses of optimized Pareto

ε	The amount of the first target function	The amount of second target function
1936	46269	1958
3820	68663	3850
5704	83403	5707
7588	170559	7597
9472	22055	9478
11356	33435	11363
13240	25311	13253
15124	58039	15144
17008	62257	17009
18900	80016	18900

Also, the Pareto paradigm is obtained as:

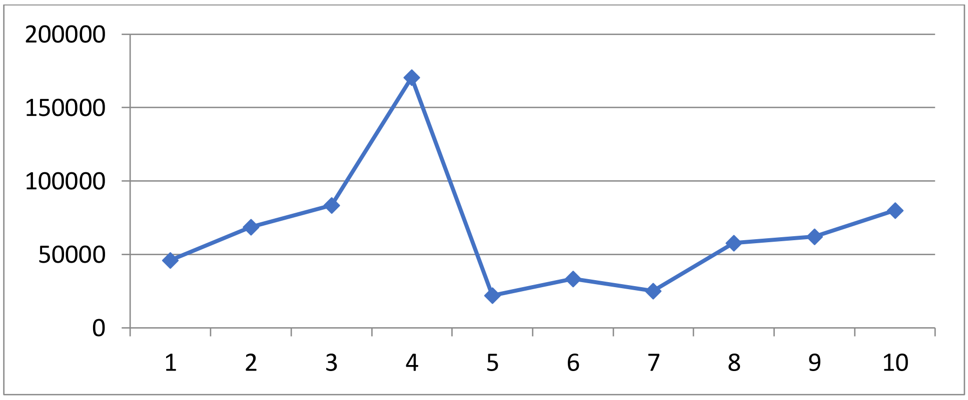

Figure 1. The ratio of the first target function to the amounts of epsilon

As it can be seen, the ratio of the first target function to the amounts of epsilon is shown that failure impact occurred in the optimization process in the first target function, and according to the conducted analysis, in this dimension is shown that in this dimension the optimized profit is reduced and the second target function also has the same trend is consistent with the increase in the amounts of epsilons. Therefore, the Pareto frontier of optimized responses is as follows:

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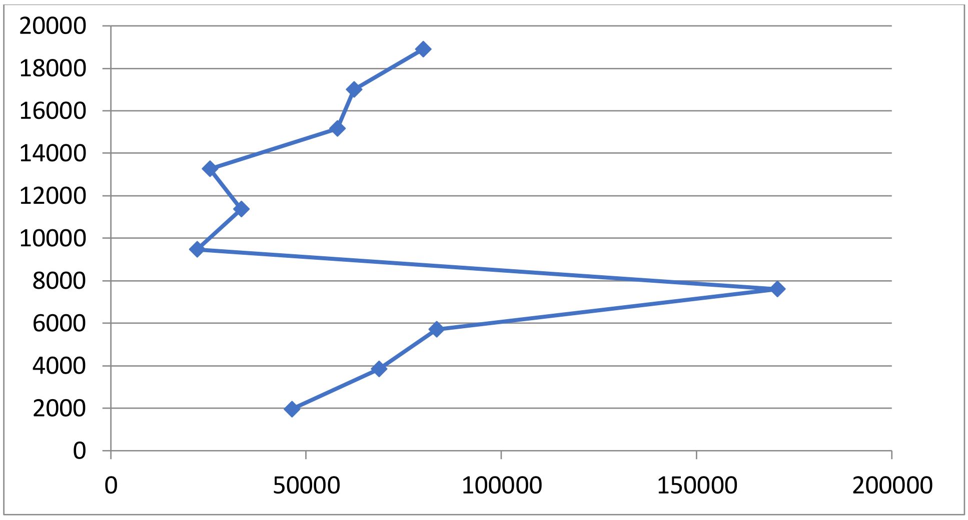

Figure 2. The Pareto frontier of the mathematical model optimized responses

Table 7. Amounts of sent products from producer to customer and distributor

T	i	X_{ijt}				S_{ikt}		
		J				K		
		1	2	2	4	1	2	3
1	1	0	0	0	18.0974	0	0	0
	2	14.363	28.726	14.363	24.9916	4.3089	4.3089	4.3089
	3	0	0	0	0	0	0	0
2	1	0	0	7.58367	0	0	0	0
	2	5.54412	0	2.06827	0	0	5.02705	0
	3	0	28.726	4.71107	0	5.7452	0	0
3	1	0	22.6217	0	0	4.3089	0	2.3699
	2	0	0	0	28.0797	0	0	0
	3	14.363	0	14.363	15.0093	0	0	2.65716

The amounts are related to the amounts of sent products from producer to customer and distributor.

Table 8. Amounts of inventory of distributors in every time period

t	J			
	1.47279	2.94558	4.41837	5.89116
1	14.7279	29.4558	14.7279	44.1837
2	20.0046	57.7334	28.8667	38.6814
3	28.2618	78.5019	42.2867	80.3791
4	27.4139	76.1469	41.0181	52.2528
5	26.4545	73.4818	39.5826	20.5778
6	25.3963	70.5425	37.9992	0.2433
7	24.2535	32.4865	36.2893	0.23226
8	23.0408	3.57873	34.4748	0.22062

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Also, table 8. shows the amounts of inventory of distributors in every time period, which, as obviously, these amounts have an upward trend until the first three time periods, and after the 4th period, these amounts are going to be reduced gradually. This is due to the fact that we have only produced products in the first three time periods.

Results of Numerical Problems

Now the appropriate parameters in each algorithm are specified after designing the experiment and arranging parameters, and it is time to implement and compare the algorithm for produced problems. Therefore, 12 problems are implemented by the MOKA algorithm.

Period	Part 1								Part 2					Part 3										Part 4			
	i			*j+k*					*j*			*k*		*i+j+k*								*l*		*l*		*o*	
1	0.072	0.132	0.876	0.988	0.799	0.641	0.385	0.650	0.897	0.674	0.115	0.243	0.122	0.490	0.986	0.218	0.516	0.026	0.346	0.961	0.352	0.310	0.288	0.581	0.581	0.401	0.776
2	0.526	0.268	0.209	0.562	0.123	0.544	0.738	0.726	0.783	0.860	0.168	0.469	0.989	0.716	0.289	0.239	0.457	0.723	0.199	0.144	0.830	0.023	0.976	0.939	0.688	0.663	0.093
3	0.099	0.332	0.034	0.383	0.339	0.431	0.997	0.350	0.792	0.313	0.852	0.512	0.391	0.382	0.472	0.304	0.894	0.471	0.635	0.043	0.534	0.494	0.120	0.854	0.904	0.140	0.209
4	0.317	0.877	0.995	0.492	0.892	0.321	0.982	0.195	0.760	0.302	0.678	0.900	0.010	0.787	0.448	0.700	0.246	0.913	0.203	0.211	0.919	0.449	0.949	0.109	0.425	0.252	0.467
5	0.077	0.771	0.215	0.814	0.055	0.230	0.934	0.830	0.240	0.606	0.543	0.721	0.773	0.991	0.513	0.001	0.611	0.156	0.458	0.465	0.5445	0.097	0.316	0.860	0.894	0.256	0.417
6	0.286	0.983	0.252	0.185	0.587	0.861	0.454	0.649	0.090	0.951	0.958	0.598	0.067	0.602	0.593	0.467	0.307	0.548	0.523	0.845	0.231	0.070	0.57	0.198	0.281	0.099	0.617
7	0.227	0.941	0.936	0.965	0.178	0.777	0.637	0.004	0.336	0.366	0.251	0.206	0.234	0.201	0.193	0.929	0.647	0.755	0.553	0.638	0.955	0.746	0.936	0.805	0.721	0.230	0.947
8	0.222	0.906	0.89*4	0.777	0.339	0.757	0.617	0.296	0.205	0.771	0.258	0.236	0.347	0.862	0.402	0.901	0.777	0.607	0.733	0.687	0.331	0.238	0.988	0.588	0.387	0.601	0.016

Figure 3. The scheme of the Chromosome of problem

As it is obvious in figure 3, every chromosome of a problem consists of four parts, and all its number fill with random numbers between (1, 0). Then we order them and use their obtained sequences as allocation sequences. It should be mentioned that this research has used programming based on priority 1.

The first part of the chromosome is related to the allocation between two levels of “producer” and “distributer +costumer” in 8 time periods. The second part of the chromosome is related to the allocation between two levels of “distributer” and “customer” in 8 time periods. The third part of the chromosome is related to the allocation between two levels of “producer+distributer+costumer” and “compost centers” in 8 time periods. The fourth part of the chromosome is related to the allocation between two levels of “compost center” and “compost customers” in 8 time periods.

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After solving the proposed mathematical model by using called methods, finally, table 9 shows obtained results for the problem.

Table 9. Calculating results from algorithms for 12 sub-problem

Problem	*NPS*	*CPU Time*	*MID*	*MS*	*SNS*
1	21	156	2	623121	485650
2	21	411	2	1189956	1218274
3	10	411	3	733666	999478
4	25	1135	4	1104737	2078257
5	16	2249	5	822806	2569381
6	15	2552	4	2355135	3480543
7	18	2781	5	1320039	3523399
8	19	7601	9	1855992	5933444
9	23	16387	13	1691351	9355409
10	13	14721	15	2142852	7974907
11	22	25452	8	3165274	9224106
12	13	21475	6	1581891	6604672

The Pareto diagram is obtained in figure 4 after solving the first problem by using mentioned methods and the exact method of constraint-epsilon; we can find out, according to the figure4., that the Pareto responses are close to the constraint-epsilon method for these proposed methods.

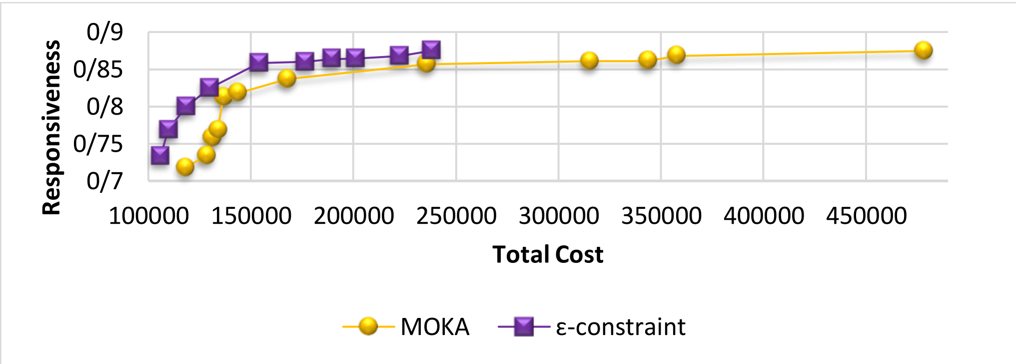

Figure 4. Pareto diagram related to the first problem

On the other hand, after calculating standard indexes for these methods, it can be seen that the results of the proposed algorithm are close to the constraint-epsilon method or even better in some cases. Table 10 shows this issue.

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Table 10. Results of evaluating model

Methods	NPS↑		CPU time↓		MID↓		MS↑		SNS↑	
	value	gap	value	gap	value	gap	value	gap	Value	gap
ε-constraint	10	0.17	261.94	15.86	1.38	0	369174.0	0	296471.86	0.18
MOKA	12	0	90.14	4.80	1.41	0.02	360138.19	0.024	280685.49	0.23

That the following formula is used to calculate the gap.

$$gap = \left| \frac{a\lg - best}{best} \right| \tag{44}$$

Discussion and Conclusion

The analysts of the supply chain area always investigate published information by companies about financial performance, which is known as the annual report. The annual report is a required legal document that should be published by all public companies. The aim of this report is that the stakeholders are presented with exact and reliable financial statements which provide the financial performance of the company. Moreover, the statements by the manager or managers of the company are confirmed and signed with a number of disclosure documents. Therefore, annual reporting shows the most comprehensive information resource about financial performance, which is available for investors annually. Annual reporting includes three parts financial statement, balance sheet, and income and cash flow statement. The financial supply chain has an important role in operational and financial activities, and academic and industrial attention has been paid to it increasingly. The history of financial supply chain research is for the years of 1970 decade, before the popularity of the term supply chain management. Badian and Ipen studied the net cash flow produced in the business operation period in a cash planning period and how net flows are influenced by changing policies related to trade and inventory credits. Holly and Higgins investigated the relationships between inventory policies and trade credit policies. The first official definition of financial supply chains appeared in 2000. the key features of the financial supply chain are the integration of financial flows in the physical supply chain, and the financial supply chain can be introduced as the necessary part of supply chain management. financial supply chain as a place for the intersection of logistics, management supply chain, and financial financing and introduced it as a method for two or more organizations in the supply chain, including external service providers, to create a mutual value by planning, guiding, and controlling the flow of financial resource in internal to the organization level . Full and Gum introduced a financial supply chain as the internal company optimization and the integrator of the financing process with customers, suppliers, and service suppliers in order to increase the value of all participating companies. Gum stated that the aim of the financial supply chain is to optimize financing within the boundaries of the company in order to reduce the accelerator capital cost to cash flow. Swafford et al. stated that key factors in logistics included sourcing, preparing, producing, logistics, and distributing. They showed in their research that the agility of a company's supply chain is influenced by the amount of flexibility and sourcing procurement and the efficiency of financial logistics positively and directly. Therefore, according to the importance of financing the

supply chain, the problem of supplying materials and financing was discussed and investigated in this research, but this issue has not been investigated and analyzed in an integrated manner yet. So, first mathematical research and modeling gap in the literature review was analyzed, and it was shown that the nature of assessing components of cash flow and materials in the supply chain and what strategy was investigated in this regard, and research gaps were introduced. Then two-objective mathematical models maximizing profits (the factors of financing income and cost) in supplying materials and minimizing the financial risk of the supply chain were argued, and the most important constraints considered in this research can be mentioned as the constraints of the capacity of suppliers, the capacity of supply warehouse and the return route of perishable products in the green supply chain. Then the composed mathematical model became close to a real situation based on constraint chance fuzzy-uncertain strategy and based on two constraint-epsilon algorithms were introduced to exact solving problem and meta-heuristic algorithm MOKA to approximate solving and finally it was shown according to conducted assessment that constraint-epsilon algorithm was more efficient in small scale and in large scale, meta-heuristic algorithm MOKA had more efficiency.

According to the research findings in regard to developing financing and materials in green supply chain topics, practical and research suggestions were introduced in this section which will be mentioned below.

Practical Suggestion of the Research

In regards to realizing the financial purposes of the organization, it is suggested to consider the problem of credit purchase in order to reduce returned costs of damaged goods to suppliers and increase the quality level of suppliers.

In regards to developing the factors of purchasing equipment, it is suggested to set resilience components as the criteria for assessing suppliers to reduce the level of occurring bullwhip in the supply chain.

It is suggested to observe the assessing and investigating issues of quality and presenting positive documents about complete compliance to the quality plan of the employer in concluded contracts with suppliers in order to improve the financial conditions of supply and quality noncompliance penalty is considered in the contracts in order to reduce the risk of financing.

Suggestions for future research are as follows:

1. Using a possibility programming approach in the produced problem to investigate the level of non-compliance of robust and fuzzy and comparing obtained responses from these two algorithms.
2. Considering lost sales in the mathematical model.

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